Mitigating systematics in weak lensing magnification and galaxy clustering

Christopher B. Morrison and Hendrik Hildebrandt

Argelander-Institut für Astronomie, Auf dem Hügel 71, 53121 Bonn, Germany

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Introduction

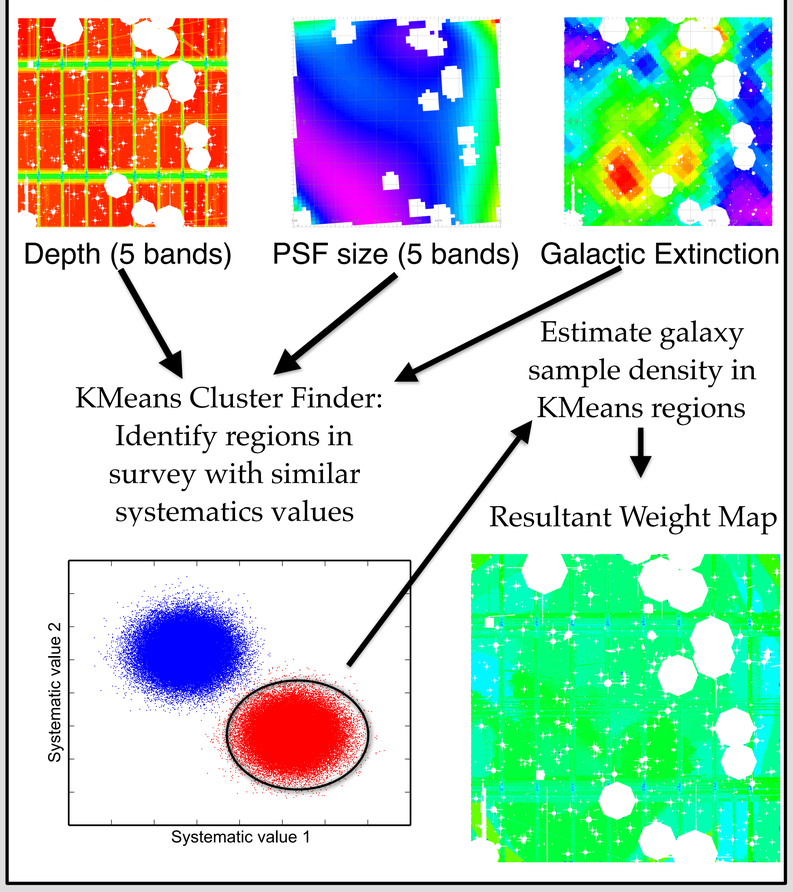
The measurement of galaxy angular correlation functions can suffer from significant contamination from systematic correlations caused by inhomogeneities in the detection pipeline from variations in survey depth, point spread function (PSF) size, and galactic extinction (e.g.). In photometric surveys these effects are not commonly corrected for except through coarse exclusion of area. The density shift of weak lensing magnification is especially sensitive to these effects due to the low signal-to-noise of the measurement and the faint galaxies used. These spurious correlations must be removed before any scientific interpretation of the signal is made.

In order to mitigate these effects we develop a method mapping the observed over-densities to the depth, seeing, etc. using machine learning. Currently we use KMeans clustering to identify regions of the survey with similar survey systematics and compute the galaxy over-density in these regions. From this mapping we create weight maps that can be used to generate random catalogs for use in an angular correlation analysis.

We apply this method to the Canada-France-Hawaii-Telescope Lensing Survey (CFHTLenS) weak lensing magnification density shift and find a significant reduction in spurious correlation from systematics especially in a sample of faint Lyman Break Galaxies (LBGs).

Method

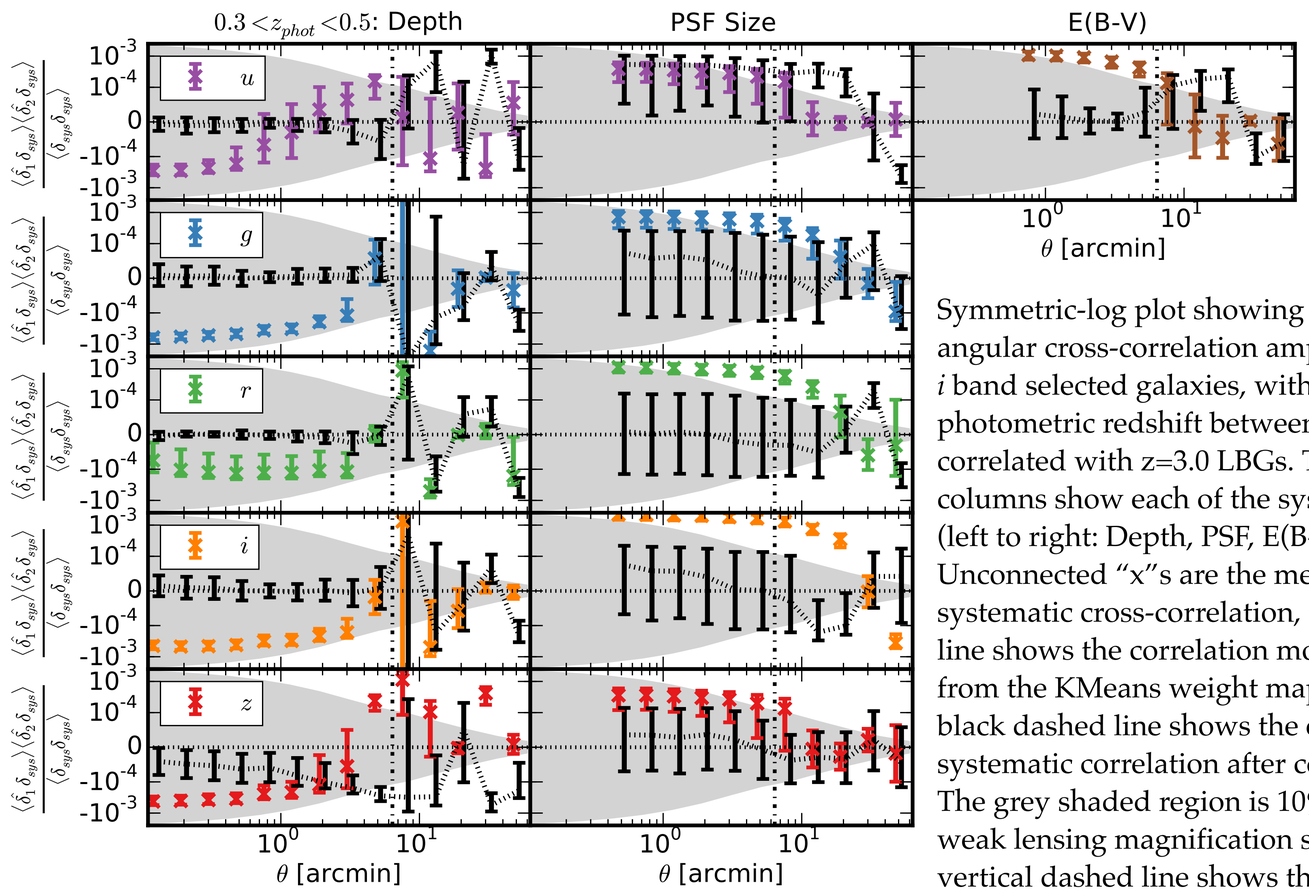
Compute systematics as a function of survey position



Results

Before correction with the random galaxy catalogs generated from the weight maps, the average galaxy sample is observed to have density fluctuations caused by survey systematics of up to ~10% compared to the mean. For the faintest samples of LBGs, we observe extreme systematic fluctuations of up to 50%. Combined, these variations result in spurious correlations that are well above 10% of the expected magnification signal. Uncorrected, this contamination will significantly bias the results of magnification analysis.

After the correction is applied, we observe a significant decrease in the amplitude of the systematic correlations, with the large majority becoming consistent with zero at all scales. Systematic correlations that are not fully removed are consistent with <10% of the signal. While we only show diagonal terms (i.e. depth cross depth), the method also gives similar results for the cross-terms.



Symmetric-log plot showing the angular cross-correlation amplitudes of *i* band selected galaxies, with photometric redshift between 0.3<z<0.5 correlated with z=3.0 LBGs. The columns show each of the systematics (left to right: Depth, PSF, E(B-V)). Unconnected "x"s are the measured systematic cross-correlation, the dashed line shows the correlation modeled from the KMeans weight maps, and the black dashed line shows the expected systematic correlation after correction. The grey shaded region is 10% of the weak lensing magnification signal. The vertical dashed line shows the scale of the narrow edge of the MegaCam CCD chips.

Conclusions

We have applied a method of mitigating the effect of density fluctuations caused by survey systematics to a weak lensing number count magnification analysis of the CFHTLenS survey. Before application of this method we observed significant spurious correlation of well over 10% of the expected signal. After, we see a reduction in the amplitude of these correlations for all samples, with the majority of these systematic correlations becoming consistent with zero at all scales. The residual systematic correlations that remain are minimal and consistent with <10% of the expected signal. This work will enable measurements of magnification in CFHTLenS.

In the future this method will be used on other multi-epoch surveys such as RCSLenS and KiDS which share similar reduction pipelines. We also hope to apply this technique to other lensing measures such as magnitude shift, size, and shear, rather than just density. Additional survey systematics will be considered as the method is easily expandable. Future surveys can benefit the technique presented here also long as proper care is given to the larger data volume both in terms of number of systematics considered and larger area / number of galaxies.

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